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ASTROPHYSICS.—*The variation of the sun.* C. G. ABBOT, F. E. FOWLE, and L. B. ALDRICH.[1]

In the year 1902 preliminary experiments were begun at Wash ington to determine the solar constant of radiation. About 700 determinations of it have now been obtained, depending on observations at altitudes ranging from sea-level to 4420 meters. As originally devised by Langley we determine spectral energy intensities and atmospheric transmission coefficients for numerous wave-lengths between about 0.30μ in the ultra-violet and 2.5μ in the infra-red, by spectrobolometric observations at high and low sun. The indications of the spectrobolometer are reduced to the standard scale of calories per square centimeter per minute by means of the readings of the pyrheliometer.

At the time when the observations were begun in 1902 there was no satisfactory establishment of the standard scale of pyrheliometry, nor indeed any pyrheliometer which was invariable relatively to itself from year to year. We at first made use of a modification of Tyndall's mercury pyrheliometer. This was improved in 1906 as the copper disk pyrheliometer, which has been in use on Mount Wilson ever since, and which is described in volume 2 of the *Annals of the Astrophysical Observatory*. A still later improvement took place in 1910 with the introduction of the so-called "Silver-Disk Pyrheliometer" which has attained considerable favor, and which is now in use in numerous countries. Neither of these instruments is capable of yielding independently

[1] Published by permission of the Secretary of the Smithsonian Institution.

the standard scale of radiation, but they possess the valuable qualities of simplicity and of being constant from year to year. Beginning with the year 1903 and extending until the end of the year 1912 we have repeatedly devised and experimented with instruments to fix the standard scale of radiation. Three of these instruments (called Water-flow Pyrheliometers Nos. 2 and 3, and Water-stir Pyrheliometer No. 4) have been tested with satisfactory results which are stated in a publication by two of us.[1] We are now satisfied that the measurements made since 1903 can be reduced to the standard scale of radiation to within 1 per cent.

Measurements of the solar constant of radiation were begun at Washington, practically at sea-level, and were continued when favorable opportunities presented themselves from October, 1902, until May, 1907. Measurements were begun on Mount Wilson in California (elevation 1730 meters) in 1905, and have been continued with the exception of 1907 during about six months in the year in each of the succeeding years. Expeditions to Mount Whitney in California, altitude 4420 meters, were made in 1908, 1909, and 1910. Expeditions to Bassour, Algeria, altitude 1160 meters, were conducted in the autumn of 1911 and the summer of 1912. In all 696 complete determinations of the solar constant of radiation have been made, and still others are unreduced. The differences found between the results at different elevations are very small, and seem attributable rather to experimental error or slight atmospheric irregularities than to any difference of elevation. The mean of all these 696 determinations made principally between the years 1905 and 1912 is

1.932 calories per square centimeter per minute.

Subject to the possibility that there may exist ultra-violet rays of appreciable intensity beyond the wave-length 0.29μ, which are cut off by the absorption of ozone from reaching the earth's surface, we believe that this value represents the intensity of the radiation of the sun as it would be found in space at the earth's mean solar distance for the epoch 1905 to 1912.

[1] See "Smithsonian Pyrheliometry Revised;" Smithsonian Miscellaneous Collections **60**: no. 18. 1913.

In the year 1903 we found indications that the radiation of the sun is not constant from day to day.[3] It has been a main object of the work to ascertain if these apparent variations of the sun are really solar, or are due to some accidental or atmospheric influences not fully eliminated. As early as the year 1910 it had been shown that practically equal solar-constant values were obtained on good days at sea-level, at 1730 and at 4420 meters elevation, and it had been shown that the apparent fluctuations of the solar radiation found on Mount Wilson from day to day marched by regular steps from high to low values and return, not fluctuating wildly as they would have done had they been due to experimental error. Accordingly it seemed from the first consideration (namely that altitude did not appear to affect the results) that the atmosphere was not the cause of the fluctuation; and from the second consideration (namely, that the values marched step by step from high to low or *vice versa*) that it was not an accidental fluctuation. Hence, the most probable conclusion was either that the radiation of the sun is actually variable, or that some meteoric or other matter, by interposition between the earth and the sun, alters the quantity of the radiation received at the earth from day to day. The fluctuations appeared to be of irregular magnitude and period, often ranging through 5 per cent or more, in an interval of seven or ten days.

However probable the result just stated might appear, it could not be fully verified without carrying out the observation simultaneously at two stations widely separated on the earth's surface, so that no local atmospheric influence could be supposed to affect both stations at once. This extension of the work was made possible by the Algerian expeditions of 1911 and 1912. Solar-constant determinations were made nearly simultaneously at Mount Wilson, California, and Bassour, Algeria, separated by about one-third of the circumference of the earth. A difference of time of about eight hours generally occurred between the observations, but inasmuch as the apparent fluctuations of the sun seldom reach 1 per cent in a day, this difference of eight hours seems not much prejudicial to the comparison.

[3] See Astrophysical Journal **19**: 305. 1903.

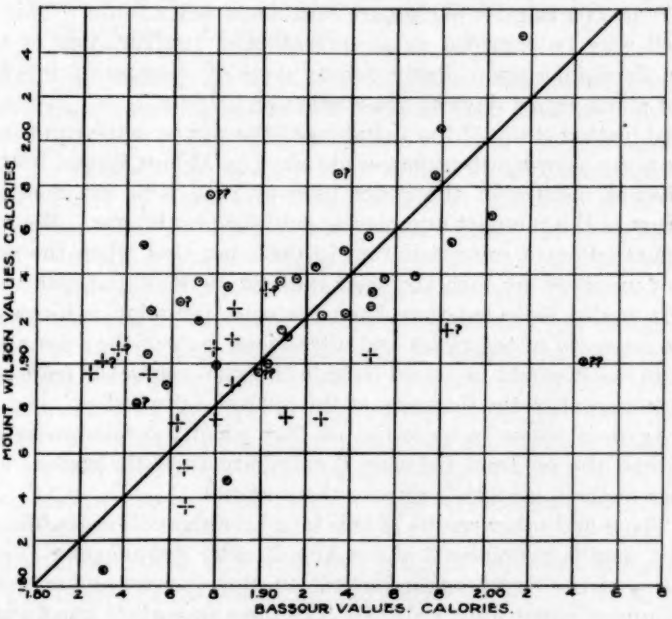
We were somewhat unlucky in our expeditions. In 1911 a box containing the bolometer and other necessary parts was delayed one month in reaching Algeria, so that a long period of good weather in August was lost. Also the months of September, October, and November, 1911, proved less favorable than usual at Mount Wilson and less favorable than had been hoped at Bassour. Thus the number of days in 1911 in which good observations were secured in both places was rather small. In the year 1912, although the sky was generally cloudless, the eruption of the volcano of Mount Katmai in Alaska of June 6 and 7 so filled the sky with haze, both at Mount Wilson and at Bassour, that a great many days of July and August were rendered unsuitable for comparison between the two stations. Thus it occurred that of 75 days in which observations were secured at both stations in the years 1911 and 1912, only 48 were found good enough for satisfactory comparisons of the solar constant values obtained.

For the purpose in view namely, to show whether the apparent fluctuation of solar radiation is due to something outside the earth, it is immaterial whether the days of observation are consecutive or not. It is only required to know whether, if high values are found at Bassour, high values will occur on the same day at Mount Wilson, and, if low values are found at Bassour, low values will be found on Mount Wilson. It matters not whether the days in question be found in one year or another, provided that they be numerous enough to exclude the probability that an agreement, if obtained, is owing wholly to chance.

The accompanying illustration gives the results of all the days found suitable for comparison between Bassour and Mount Wilson. Ordinates are solar constant values as obtained at Mount Wilson, abscissae are solar constant values as obtained at Bassour. Circles represent the results of days of the year 1912, and crosses represent the results of days of the year 1911. If the solar radiation had varied, and all determinations of it had been free from error, the points must all have lain upon the straight line inclined at 45 degrees to the axis. As it is impossible that results shall be entirely free from error, we must expect that the points representing individual days will be well represented by the 45 degree

line if the sun is variable, but will fall uniformily distributed about one point on that line if the sun's radiation is constant. There is no difficulty in deciding that the line and not some single point of the line best represents the results here given.

The variation of the sun shown between the extreme observations amounts to 11 per cent, and many observations unite in



showing a variation of 7 per cent. The average deviation of the separate determinations at Bassour from those of the same days at Mount Wilson is 1.6 per cent.

Hence the average deviation of a single day of solar-constant measurement at one station will be $\left(\frac{1.6}{\sqrt{2}} =\right)$ 1.1 per cent, and the probable error of a single solar-constant measurement at one

station will be 0.9 per cent. Had the condition of the sky in 1912 been free from the haze which prevailed owing to the volcanic eruption of Mount Katmai, we believe the probable error of the separate determinations of 1912 would have scarcely reached 0.5 per cent.

It will be seen that the measurements of 1912 are on the average above those of 1911, at both stations. The difference 1912–1911 is 0.03 calories per square centimeter per minute. This in itself may be regarded as an indication of the variation of the sun depending upon nearly twenty days of observation in 1911 and about thirty days of observation of 1912.

In further study of the variation of the sun we have compared the mean solar-constant values obtained on Mount Wilson for the different months of the years 1905 to 1912 with the monthly values of the sun-spot numbers as published by Wolfer. We find a fluctuation of solar radiation in the sense that when the sun-spot numbers are high the solar radiation is high and *vice versa*.

It is also indicated that when the solar radiation is increased the intensity of the violet and ultra-violet rays of the solar spectrum (as it would be found outside the atmosphere) is increased with respect to the intensity of the red and infra-red.

Again it seems to be indicated that when the solar radiation is high the contrast between the brightness of the centers and edge of the solar disk is greater than normal.

These and other results of this long investigation are published with details in volume 3 of the *Annals of the Astrophysical Observatory* of the Smithsonian Institution, now in press and expected to appear about July 1, 1913. The most important conclusions are as follows:

1. The mean value of the solar constant of radiation for the epoch 1905–1912 is 1.932 calories per square centimeter per minute.

2. An increase of 0.07 calories per square centimeter per minute in the "solar constant" accompanies an increase of 100 sun-spot numbers.

3. An irregular variation frequently ranging over 0.07 calories per square centimeter per minute within an interval of ten days

is established by numerous nearly simultaneous measurements at Mount Wilson, California, and Bassour, Algeria.

4. Indications of two wholly independent kinds incline us to think that these variations of solar radiation are caused within the sun, and not by interposing meteoric or other matter.

PHYSICS.—*The melting points of some refractory oxides.* C. W. KANOLT, Bureau of Standards. To appear in the Bulletin of the Bureau of Standards.

Altho a considerable number of oxides are used as refractory materials, the melting points of but few of them have been determined, and many of the determinations that have been made are quite uncertain. For example, some of the determinations would indicate that lime and magnesia are more fusible than alumina, which can easily be demonstrated to be untrue, for alumina is readily fused in the oxyhydrogen flame, while pure lime and pure magnesia are infusible in it, at least under ordinary conditions.

The principal difficulties encountered in the accurate determination of the melting points are the production of very high temperatures uniform thru a sufficient space and controllable; the supporting of the oxide in the furnace without its contamination by the material used as a support; the avoidance of smoke, which would interfere with the measurement of temperature by an optical pyrometer; and, finally, the accurate measurement of temperature.

The furnace used was an Arsem graphite resistance furnace, with some minor modifications. This furnace was designed to be used with a vacuum, which prevents the oxidation of the graphite and diminishes the heat losses. It was found impossible, however, to melt lime or magnesia in a vacuum, for they are completely vaporized before the melting point is reached. When these oxides were melted, and also in some other cases, the furnace was filled with a non-oxidizing gas, such as hydrogen, under atmospheric pressure.

The temperatures were determined by means of a Morse optical pyrometer of the Holborn-Kurlbaum type, which was sighted ver-

tically downward thru a glass window in the top of the furnace. The carbon-filament pyrometer lamps were calibrated against the following melting points:

Material	*Melting point degrees*
Antimony	630
Copper-silver eutetic	779
Silver	960.5
Copper	1083
Diopside	1391

These materials were melted in graphite crucibles, the pyrometer being sighted into a thin-walled graphite tube inserted in the metal. Heating curves or cooling curves were plotted.

As the temperatures to be measured were far above the working limit of the pyrometer lamps, absorption glasses were interposed between the pyrometer and the furnace. The true temperatures were then found from the apparent temperatures measured thru the glasses, by means of the equation:

$$\frac{1}{T_2} - \frac{1}{T_1} = A$$

where T_1 is the absolute temperature of the furnace, T_2 is the apparent temperature observed thru the glasses, and A is a constant. The value of A for each glass or combination of glasses used was determined by sighting the pyrometer at a black body held at a constant temperature within the working limit of the pyrometer lamps, and taking readings alternately with and without the interposition of the glass. It was found that a small error might be introduced by the lag of the pyrometer lamp when its temperature was thus changed at short intervals. This was avoided by using two pyrometer lamps, each maintained approximately at one of the temperatures to be measured. A correction was applied for the absorption and reflection of the glass window of the furnace.

It was found that measurements of the same high temperature made with different pyrometer lamps or different absorption glasses were always in satisfactory agreement. As a check upon the work five determinations of the melting point of platinum

were made. The value of this fixed point accepted by the Bureau of Standards is 1755°. The platinum was melted in magnesium aluminate tubes in an iridium furnace, and both heating and cooling curves were plotted. The weighted mean of the five determinations was 1755°, with an average deviation of 5°.

The problem of avoiding smoke when the oxides are not heated in a vacuum has received very little attention in previous work, and is probably responsible for many low results It was found that errors from the presence of smoke could be avoided by introducing into the oxide to be melted a tube of suitable material into which the pyrometer was sighted, and keeping this tube clear by a gentle current of gas. The cooling effect of the gas was found to be quite negligible. With this apparatus it is impossible to see the oxide while it is melting, but as all melting points were determined by heating curves, this is not necessary. All determinations were checked by the examination of samples that had been heated to temperatures slightly below that obtained for the melting point, and also of samples heated slightly above the melting point.

Magnesia was melted in graphite crucibles, for it forms no carbide at high temperatures. It does react with carbon with the formation of carbon monoxide and magnesium vapor, as shown by Watts; but this introduces no contamination into the magnesia. The determinations were made at atmospheric pressure to avoid too rapid vaporization of the magnesia and smoke was avoided by the introduction of a graphite tube thru which gas was blown.

Lime forms carbide rapidly in contact with graphite at high temperatures; graphite is therefore out of the question as a crucible material. Lime was successfully melted in tungsten crucibles with an inner tube of tungsten, thru which hydrogen was blown. Three results in excellent agreement were obtained in this way, but the tungsten usually melted as soon as the lime had melted. This was probably the result in part of contamination of the tungsten by carbon, but the tungsten also appeared to be contaminated by contact with the fused lime, perhaps with the formation of metallic calcium. This led to the suspicion that the

melting point of the lime might be changed by the presence of the tungsten. To confirm the results another method was used. A tube made of lime was inserted into the furnace, being supported by the upper end, which was at a low temperature, while the lower end extended into the hot part of the furnace. The tube was kept free from smoke by a gentle current of hydrogen, which passed out thru a small oblique opening at the bottom. The pyrometer was sighted down the tube and a heating curve was plotted. Determinations made in this way were in close agreement with those made in tungsten crucibles. It is believed that this method will be very useful with other substances for which it is difficult to find crucible materials.

Alumina can be melted in a vacuum high enough to avoid all smoke without vaporizing so rapidly as to cause serious trouble. Determinations were made in this way with both tungsten and graphite crucibles. When the alumina was melted in graphite it did not form appreciable carbide until after it had completely melted and the melting point had been determined; and then the contamination was not rapid. The results with graphite crucibles and tungsten crucibles were in agreement. Determinations were also made at atmospheric pressure with the apparatus constructed for magnesia, the smoke being removed by a current of gas. These results agree with the others.

Chromium oxide was melted in tungsten crucibles in a vacuum. When melted in graphite it is rapidly reduced.

The results are summarized in the following table:

OXIDE	MELTING POINT CENTIGRADE	NUMBER OF DETERMINATIONS	AVERAGE DEVIATION
	degrees		*degrees*
MgO	2800	6	13
CaO	2570	5	3
Al_2O_3	2050	8	4
Cr_2O_3	1990	5	6

PHYSICS.—*New modified thermoelectric methods in calorimetry.* WALTER P. WHITE. Geophysical Laboratory. Communicated by A. L. Day.

In the common calorimetric method, the "Method of Mixtures," the work of the last five years has shown that the error due to heat loss from the calorimeter into the air, once thought to be an unconquerable foe to accuracy, is, in fact, ordinarily quite negligible. With a proper installation, the attainment of very high precision, to 0.1 per mille or better, requires merely sufficient precision in the temperature measurement. Such precision has been attained for ordinary systems by using electric thermometers. It remains to make the operation of these thermometers as simple and as free as possible from experimental precautions and corrections, to facilitate the attainment of unusual precision where this is desirable, and to take advantage of the facilities which the electrical system offers for making various measurements such as could not be attempted with the older mercury thermometers.

For a variety of measurements the thermoelectric thermometer system is especially well adapted, as has already been shown elsewhere. The present paper deals with the securing of certainty and high precision by means of the thermoelement. The essential feature of the methods is to use, around the "cold junction" of the thermoelement, in place of an ice bath, a body at nearly the same temperature as the calorimeter. The smallness of the electrical quantity to be measured then gives to the temperature measurement extraordinary precision combined with extraordinary ease. These methods, accordingly, while specially advantageous for precision in determining very small heat quantities, are in nearly all cases among the best in convenience and certainty.

Determinations of great delicacy have already been made on this principle, especially in Nernst's laboratory. In these the other body was a twin calorimeter. If the two calorimeters are alike, the external temperature and its changes affect both alike, and hence have but a slight effect upon the thermoelement read-

ing which measures the difference in the temperatures of the two. It is thus possible to proceed almost as if the external temperature had no effect at all. This has been claimed as a second great advantage of the twin method. A complete jacket, however, is much more effective in this direction, and, on the other hand, there is a cooling correction error peculiar to the twin method. It arises whenever the two calorimeters are not exactly alike, and can easily be shown to be $(K_a - K_b) \cdot (\theta_b - \theta_j)$ where K_a and K_b are the cooling rates of the two calorimeters, θ_b and θ_j the temperatures of the comparison calorimeter and of the jacket, respectively. This error is nearly eliminated if three observation periods are run (as in the usual Pfaundler Method with one calorimeter), but it can be more easily avoided by making the temperature difference, $\theta_b - \theta_j$, small, say below 0.2°. Only two observation periods are then needed.

The trouble of the temperature adjustment is largely or wholly avoided by either of two schemes, both of which utilize the low cooling rate of a vacuum-jacketed flask, which is used for the comparison calorimeter. In one scheme, a regulator keeps the jacket temperature constant. The flask is then constant to a very high degree of precision (easily to 0.0001°) without any further attention whatever. This has been called the *constant comparison body method.*

The other scheme avoids the regulator. A specially adjusted (shunted) thermoelement is used in determining the cooling correction. The two unlike calorimeters can then be operated as easily and conveniently as if they were twins, but the temperature adjustment is so much less exacting as to be almost negligible. This has been called the *compensated calorimeter method.* A combination of the two methods can be made at will, either temporarily or permanently, involves no difficulties, and reduces precautions and corrections to a very low minimum.

The gain in simplicity and ease of construction by using vacuum-jacketed bottles is evident. An effective and particularly simple way of using the bottle is to immerse it wholly in the jacket water, with an inverted cap over it containing air. A tube running down thru the cap allows the thermoelement to be

inserted or withdrawn at will without escape of air. The jacket water surrounding the thermoelement above the cap insures definite conditions as to temperature.

The best of these methods call for a complete inclosure by the jacket, but this is almost indispensable in any calorimetry of precision, and can be easily obtained. For instance, the calorimeter chamber may be a cylindrical pot, suspended in a commercial paper tub. The cover is a square box, filled with water, and closed, save for two pipes which project downward thru the surface of the water below and so provide for a complete circulation. The protection against evaporation of the jacket water which is usually necessary for precision work is very easily secured by a layer of paraffin cast on the surface of the water. This layer can of course be easily sawed or recast. By a suitable and rather evident arrangement of thermoelements, any of these schemes can be operated with the two calorimeters in two separate jackets. This procedure is necessary in the case of adiabatic methods. A precision of 0.0001° is very easily reached, under fair conditions, with a thermoelement of 24 couples. Elements of 8 couples, ordinarily precise to 0.0003°, are so very compact that the use of anything smaller will rarely be advisable.

Work with these methods has emphasized the desirability of providing, not only abundant thermometric sensitiveness, but, especially, a thoro and uniform jacket inclosure, with vigorous stirring thru wide openings. The trouble required fof these precautions is slight in itself, and is insignificant compared to that likely to be entailed by trying to dispense with them.

The requirements of these methods in the way of auxiliary electrical apparatus (potentiometer, etc.) are unusually simple and inexpensive, but are nevertheless exacting in certain directions. Elaborate apparatus and methods, admirable for other kinds of work, may fail here, tho success is easy by appropriate arrangements. A revised account of the essential requirements is in preparation. The great advantage of these methods is in the ease and precision of the temperature measurement. Otherwise, they present disadvantages, which, however, are evidently slight, and far outweighed by the advantages.

PHYSICS.—*On the absorption of light in heterogeneous media.* P. G. NUTTING. Eastman Kodak Company. Rochester, N. Y.

Photographic density depends upon the size and number of the imbedded silver grains and to a slight extent upon their form and distribution as well. The mathematical problem of relating density to grain is obviously to be treated by probability theory rather than by infinitesimal analysis. The solution here presented will be of interest to students of the theories of radiation and of entropy in discontinuous systems, in that it is a much simpler problem treated by similar probability methods.

Suppose snowflakes of a given size to be falling with perfect irregularity upon a surface. When a given number per unit area have fallen, what will be the mean relative areas covered and uncovered? In the plate grain problem as in the snowflake problem, the distribution is completely irregular, but in a volume instead of a plane. The grains are contained in a layer of the order of 10 to 20μ thick and are themselves 0.5 to 3μ in diameter, irregular in outline and fairly uniform in area in any one plate. The grains are not crystals, but aggregates of finely divided silver resembling platinum black or soot, of very high absorbing and low reflecting power. This reflecting power has not yet been directly determined, but estimates based on scattering make it well under 2 per cent. In the following discussion both *reflection* and *diffusion* are neglected, tho both may be readily entered in the equations.

Consider the absorbing body divided into layers about 1 grain thick, parallel with the surface, so that there will be but a negligible amount of overlapping of grains in any one layer. That certain grains lie partly in two successive layers is of no consequence, since in the equations they are counted but once in the layer in which their greater bulk lies. In the first layer let there be n_1, grains per unit area and let a_1 be their average projected area. Then the probability of a ray of light being stopped by this layer is the ratio of the covered to the total area, or as $n_1 a_1$ to 1. Similarly the probability of a ray passing the first layer is

$1 - n_1 a_1$. In other words the absorption and transmission *coefficients* are respectively the *probabilities* of being stopped and of being passed.

In the second layer let the corresponding quantities be n_2 and a_2, in the third n_3 and a_3 and so on. For brevity call the product $n_1 a_1 \equiv A_1$, etc. Now the only manner in which a ray may pass thru all layers is to pass each layer separately hence the probability of passing all layers is the continued product

$$(1 - A_1)(1 - A_2) \ . \ . \ . \ . \ (1 - A_m) \equiv T_m \qquad (1)$$

of the probabilities of passing each separate layer. This is the *transparency* of the whole sheet. The corresponding absorption B_m is the complementary quantity

$$B_m = 1 - T_m \qquad (2)$$

It may be noted that the absorption of the whole is not the product $(A_1 A_2 \ . \ . \ . \ A_m)$ of the probabilities of absorption in the various layers since the action is not alike in all layers, a ray may be passed by several layers to be stopped in another. The above product $(A_1 A_2 \ . \ . \ . \ A_2)$ is the probability of possible stoppage in *all* layers, i.e., the probability per unit area of a continuous train of grains lying one behind the other, thru all the successive m layers. In fact, if the value of T_m in (1) be written in (2), multiplied out and grouped according to the number of A's multiplied together, then each group gives the probability of 2, 3 . . . m grains overlapping.

In the special case of all layers alike in number and size of grain, the transparency of all m layers will be

$$T_m = (1 - A)^m \qquad (3)$$

since in (1) $A_1 = A_2, = \ . \ . \ . \ = A_m$. This corresponds to *Beer's Law* in ordinary optics.

Photographic *density* D has of late years been precisely defined by the relation

$$D = - \log_{10} T \qquad (4)$$

T being the transparency in the sense used above. The value of T_m in either (1) or (3) may be substituted in (4) according to

conditions. Equations (1) and (4) give the general relation sought between density and the number, size and distribution of grain.

In all ordinary practice the size and distribution of grain thruout the film is so uniform that (3) gives a very close approximation indeed. In this case.

$$D = -m \log (1 - A). \tag{5}$$

If further A is so small that the overlapping of grains is negligible, as is the case with low and medium densities,

$$D = m A = m n a \tag{6}$$

The ratio of the mass of reduced silver per unit area to the density (4) is an important quantity, the so-called *photographic constant.*

Now the film is m layers deep, hence $m\ n = N$ is the whole number of grains per unit area. Mass of silver (M), per unit area is then proportional to N and to the average volume of the grains,

$$M = c N a^{3/2}, \tag{7}$$

the constant c involving the specific gravity of the silver and certain numerical factors.

The photographic constant (P), defined as mass of silver per unit area per unit density, is then

$$P = \frac{M}{D} = \frac{cNa^{3/2}}{Na} = c\sqrt{a} \tag{8}$$

if the overlapping of grains is negligible, or is

$$P = -\frac{cNa^{3/2}}{\Sigma \log (1-na)} \tag{9}$$

without assumptions as to overlapping or uniformity of grain thru the film.

From these equations it appears that P, to a first approximation, is independent of N and hence of exposure and development, but that it will vary among different brands of plates in proportion to the mean diameter of grain. The first of these conclu-

sions is a well known experimental fact. P is of the order of 10 mg. of silver per square decimeter of film, per unit density. The relation between P and size of grain has not yet received experimental confirmation, tho P is known to vary in different kinds of plate.

In the following table are numerical values calculated for different photographic densities.

TABLE I

D	T	$1-A$	A	$10\,A$
5	0 00001	0.316	0.684	6.8
3	0 001	0.501	0.499	5.0
2	0.010	0.631	0.369	3.7
1	0.100	0.794	0.206	2.1
0.7	0.200	0.851	0.149	1.5
0.5	0.316	0.891	0.109	1.1
0.2	0.631	0.955	0.045	0.45
0.1	0.794	0.977	0.023	0.23

T is the fraction of the light transmitted by the entire thickness of film, $1 - A$ is the corresponding transmission of any single layer 1 grain deep while A is the fraction absorbed, on an average, in any single layer. The final column, $10\,A$, is what the absorption of a film 10 grains deep (an ordinary film) would be if each grain were fully effective. Thus, for unit density, the transparency is 10 per cent, the absorption of a single layer 20 per cent and there are present 2.1 times as many grains as would completely cover a surface.

Taking the particular case of unit density and $A_1 = 20$ per cent (0.20) and computing the absorption of the first n layers by the formula

$$B_{1\ldots n} = 1 - T_n = 1 - (1 - A)^n,$$
$$B_1 = A = 0.20,\ B_{1,2} = 2A - A_2 = 0.4 - 0.04 = 0.36$$

that is, in the first two layers 36 per cent is covered and 4 per cent of this covered twice. In the first three layers

$$B_{1..3} = 3A - 3A^2 + A^3 = 0.60 - 0.12 + 0.008 = 0.488$$

the probability of overlapping is 0.12, of triple overlapping of grains is 0.008. Tabulating for *ten* layers,

TABLE II

n	T_n	B_n	ΔB_n	A^n	${}_nP_{10}$
			per cent		
1	0.794	0.206		0.21	2.06
2	0.633	0.367	16.1	0.04	1.80
3	0.501	0.499	13.2	0.008	0.96
4	0.398	0.602	10.3	0.0016	0.336
5	0.316	0.684	8.2	0.0_332	0.080
6	0.251	0.749	6.5	0.0_464	0.013
7	0.200	0.800	5.1	0.0_513	0.0017
8	0.159	0.841	4.1	0.0_626	0.0_312
9	0.126	0.874	3.3	0.0_651	0.0_352
10	0.100	0.900	2.6	0.0_610	0.0_610

The second and third columns give respectively the *transparency* and *absorption* of the first n layers. The fourth column gives the increment of absorption due to the nth layer. The fifth column gives the probability of n grains overlapping in n layers. The last column gives the probability of n grains being in line in all ten layers, it is A^n 10! / N! (10-n)!

RADIOTELEGRAPHY.—*Difference in strength of day and night signals in radiotelegraphy.* L. W. AUSTIN, U. S. Naval Radiotelegraphic Laboratory.

The first explanation, given of the difference in strength of day and night signals after the discovery of the phenomenon by Marconi, was that sunlight, by ionizing the air around the sending antenna, produced energy losses which resulted in a decrease in the strength of the received signals. This idea has long been abandoned as affording a full explanation of the phenomenon. Recent observations between the Arlington station and the station at the Bureau of Standards, 8 kilometers apart, show that if the effect exists at all it is a matter of not more than 1 or 2 per cent.

At a later period it was supposed by many workers in radio-

telegraphy that the increase in strength of signals at night was caused by the decrease in an absorption in the upper conducting layers of the atmosphere after the ionization due to the sunlight and possible cathode rays from the sun had ceased.

The data accumulated by the U. S. Navy Department during the last three years appear to make this explanation improbable for the two following reasons: (1) It is known that in certain regions and at certain wave lengths the ground absorption is more than twenty times as great as would be the case if the signals were sent over salt water. The sun's rays can hardly be thought to affect the losses in the earth to any extent, yet on some nights these waves travel across the same region, reaching the receiving station with as great strength as would have been the case if there had been no absorption at all.[1] (2) Observations on undamped oscillations from the arc have shown that at night there is a selective strengthening and weakening of the signals with changing wave length. For example, during the recent tests of the arc at Arlington, it was found that when the night signals at the receiving station were faint at the regular wave length of 4100 meters, changing to 3950 meters would almost invariably bring them in with greatly increased strength and *vice versa*. This suggests the light and dark interference bands of optics and, as Dr. De Forest has suggested,[2] the phenomenon may be explained by the interference of a set of waves traveling along the earth's surface with another set which has been reflected from the conducting layers of the upper atmosphere. Calculations show that the height of the reflecting surface would be from 40 to 60 miles, which are very probable values for the point at which conductivity would begin. This phenomenon has been observed so constantly in the work with the arc that there can be absolutely no doubt of its existence. The fact that it has not been observed in the case of spark waves is due partly to the fact that spark apparatus is generally not changed in wave length by such small

[1] In many well authenticated cases signals have been received with more than twice the strength which the simple Duddell and Taylor law would have indicated.

[2] Proc. Inst. Radio Engineers 1: 37. 1913.

percentage steps, and partly to the shortness of the wave trains which would not permit the direct and deflected trains to overlap for any considerable difference of path.

These facts indicate that the greater strength of night signals is probably due not to a decrease in absorption, but rather to additional energy which reaches the receiving station by reflection. This explanation would involve the idea that at night the upper atmosphere becomes stratified in such a way that at some given height differing at different times, there is a sufficiently sudden change in conductivity to permit reflection. It is conceivable that this stratification is broken up in the day time either by vertical convection currents, or by the more or less irregular ionization produced by the ultra violet rays or cathode particles from the sun.[3]

It is certain that the difference between night and day signals is much less at long waves than at short, but the observations on the Clifden signals (λ about 7000 meters) at Brant Rock (2460 miles) and at Arlington (2840 miles) do not agree with the observations of Marconi at Glace Bay that the day signals are equal to or better than those at night.[4] At Brant Rock during the autumn and winter the received current from Clifden thru 25 ohms resistance was in general about 35.10^{-6} amp. in the day time, rising at times to 55.10^{-6} amp., while at night the current frequently amounted to more than 100.10^{-6} amp. In summer the signals were always faint and much of the time inaudible in the day time, varying probably between 7.10^{-6} and 12.10^{-6} amp. Night signals were much louder, no exact measurements being made on them. The observations on Clifden at Arlington agree qualitatively with the Brant Rock results.

[3] The difference in summer and winter day signals at great distances perhaps indicates that reflection plays some part even in the day time.

[4] It is conceivable that the directive receiving antenna at Glace Bay may have an influence on the phenomenon.

METALLOGRAPHY.—*Preliminary note on the critical ranges, A3 and A2, of pure iron.* G. K. BURGESS and J. J. CROWE, Bureau of Standards.

In view of the recent publication by Professor Carpenter of his very interesting results[1] on this subject and considering its theoretical importance, we deem it advisable at this time to give a brief account of some preliminary observations taken in 1911 and 1912 on the location of the critical ranges in pure iron both on heating and cooling. We had intended deferring publication until results were ready on a specially pure sample of iron prepared here by Mr. J. R. Cain. Since, however, with five samples of iron of the same order of purity as the single one used by Professor Carpenter (99.97 per cent Fe) we are not able to reach the same conclusion he does, namely, "that were it possible to remove the last traces of impurity, iron would cease to show even these faint indications of Ar2," it may be of interest to put on record now some of the results so far obtained. Cooling and heating curves of five samples of electrolytic iron have been taken *in vacuo*, three samples being separate preparations in the form of cathode plates from Prof. C. F. Burgess of Wisconsin; and two samples remelted by us *in vacuo* to remove gases, one prepared by the Langheim-Pfanhauser A. G. furnished by Dr. H. Goldschmidt and one a sample of the C. F. Burgess iron. The samples weighed from 21 to 31 grams.

Two methods of locating the critical ranges were used simultaneously, requiring two observers. The first was the Osmond inverse-rate method, times being recorded to 0.1 second on a cylindrical chronograph and temperatures taken in steps of 2°C. by means of a Diesselhorst potentiometer.

The second was the Roberts-Austen differential method with a platinum neutral and reduced by Rosenhain's derived differential method. The plotted curves should be strictly similar in shape, and in practice, unless something is the matter, they are similar.

Using a specially designed liquid rheostat, it was possible to

[1] H. C. H. Carpenter, The critical ranges of pure iron. Iron and Steel Institute, May, 1913.

PRELIMINARY OBSERVATIONS ON CRITICAL RANGES OF IRON

Beginning

SAMPLE	*Ac1*	*Ac2*	*Ac3*	*Ar3*	*Ar2*	*Ar1*	NUMBER OF OBSERVATIONS	DATE
C. F. Burgess No. 1		768	904	902	774		4	7/25–28/1911
C. F. Burgess No. 2	698?	767	909	912	778		6	11/ 8–13/1911
C. F. Burgess No. 3		737?		903	774		5	11/21,12/4/1911
C. F. Burgess No. 3 remelted in vacuo	692?	735?	917	911	780		7	7/19/,10/22/1912
Langheim-Pfanhauser			919	917	855?		7	8/14–29/1912
Approximate Means		765	910	909	775			

Maximum

SAMPLE	*Ac1*	*Ac2*	*Ac3*	*Ar3*	*Ar2*	*Ar1*	NUMBER OF OBSERVATIONS	DATE
C. F. Burgess No. 1		789	934	895	768		4	
C. F. Burgess No. 2	704?	789	924	901	764	703?	6	
C. F. Burgess No. 3		778	920	897	769	?	5	
C. F. Burgess No. 3 remelted in vacuo	?	774	921	908	775		7	
Langheim-Pfanhauser		774	922	912	775		7	
Approximate Means		781	924	903	768			

PRELIMINARY OBSERVATIONS ON CRITICAL POINTS OF IRON—Continued

End

SAMPLE	Ac1	Ac2	Ac3	Ar3	Ar2	Ar1	NUMBER OF OBSERVATIONS	DATE
C. F. Burgess No. 1		814	948	874	724		4	
C. F. Burgess No. 2	730?	806	933	887	720?	682?	6	
C. F. Burgess No. 3		782?	933	874			5	
C. F. Burgess No. 3 remelted in vacuo		783	934	896	756		7	
Langheim-Pfanhauser		783	934	901	744		7	
Approximate Means		795	935	890	740			

ANALYSES	C. F. BURGESS NO. 1	LANGHEIM-PFANHAUSER
	per cent	*per cent*
S	0.00	0.00
Si	0.013	0.00
P	0.004	0.007
Mn	0.00	0.00
C	0.012	0.00
Cu		0.008
H	0.072	?

adjust for a practically constant rate of heating and cooling over the whole temperature range, 500° to 1100°C. Measurements were taken at rates ranging from three seconds per degree to thirty-six seconds per degree with no considerable effect upon the location or magnitude of the critical ranges. The heating of the furnace was by alternating current from a motor generator run from a storage battery. The results are shown in the accompanying table; the analyses were furnished by Prof. C. F. Burgess and Dr. H. Goldschmidt. It will be noted that for the remelted samples the maxima for Ac2 and Ar2 are identical in position. The plotted curves show Ac2 as pronounced as Ar2 for all the samples. A2 and A3 appear to be different in kind, but the discussion of this subject we prefer to defer until more complete data and check analyses are obtained.

It should also be noted that in 1909, A. Müller[2] published a careful study of the critical ranges of electrolytic iron finding Ac2 = 770°, Ar2 = 763°, Ac3 = 917° and Ar3 = 894°.

[2] A. Müller, Über die Darstellung des Elektrolyteisens, dessen Zuzammensetzung und thermische Eizenschaften. Metallurgie 6: 145. 1909.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

METEOROLOGY.—*Hurricanes of the West Indies.* OLIVER L. FASSIG. Weather Bureau Bulletin **10**: pp. 28, pls. 25. 1913.

The early completion of the Panama Canal makes the present appearance of a good bulletin on the hurricanes of the West Indies peculiarly timely, and the one under consideration fully meets the needs of all who are likely to be interested in this subject. The text is divided as follows: (1) Hurricane areas and hurricane tracks; (2) Frequency of hurricanes; (3) Progressive movement of hurricanes; (4) Duration and intensity of hurricanes; (5) Hurricanes, cyclones, and typhoons; (6) Signs of an approaching tropical cyclone; (7) The hurricane of August 7–20, 1899; (8) Origin of tropical cyclones. The chief feature of the bulletin is its excellent colored charts, which tell at a glance practically the whole hurricane story. W. J. HUMPHREYS.

METEOROLOGY.—*On the physics of the atmosphere.* W. J. HUMPHREYS. Journal of the Franklin Institute. **175**: 207–244. 1913.

In this article a number of physical phenomena of the atmosphere are described and their explanations given. Such as: (1) Vertical temperature gradients as determined by sounding balloons; (2) Composition of the atmosphere at various elevations; (3) Density of the atmosphere at different levels; (4) The nature and cause of the isothermal region; (5) The origin and the climatic effects of the permanent centers of high pressure on the oceans; (6) The structure of the wind, including wind layers, gusts, and cases of violent vertical convection; (7) The origin of thunder-storm electricity. There are also thirteen illustrations that make it easier for the reader to follow the text. W. J. H.

CLIMATOLOGY.—*Two climatic cross-sections of the United States.* ROBERT DE C. WARD. Monthly Weather Review **40**, 1909–1917. 1913.

Professor Ward had the good fortune to take the whole of the 13,000 mile "Transcontinental Excursion of the American Geographical Society," August 22 to October 18, 1912, and had therefore an unusual opportunity of studying at first hand the effects of the numerous climates of this country on topography, plant growth, and human industry. All these he describes in an article that follows the excursion up the Hudson, along the Great Lakes, thru the Bad Lands, among the Geysers, down the Grand Coulée, over the wheat fields, orchards and vineyards of Washington, Oregon and California, across the Sierras, along the old beaches of Lake Bonneville, among the mountains and down the canyons of Colorado, thru the wonderful scenery of Arizona and New Mexico, down the Mississippi, across the southern Appalachians, and along the Piedmont Region by way of Washington, D. C., back to New York. Every climatic section of the United States was visited on this trip, and to each Professor Ward has given its due share of attention.

W. J. HUMPHREYS.

CHEMISTRY.—*The action of potassium amide on cupric nitrate in liquid ammonia solution.* EDWARD C. FRANKLIN. Hygienic Laboratory. Journal American Chemical Society, **34**: 1501. 1912.

Instead of giving a precipitate of cuprous amide as might be expected, cupric nitrate in solution in liquid ammonia reacts with potassium amide to form ammonated cuprous nitride in accordance with the equation $3Cu(NO_3)_2 + 6KNH_2 = Cu_3N.nNH_3 + 6KNO_3 + (4\text{-}n)NH_3 + N$. When heated *in vacuo* to laboratory temperature the precipitate loses ammonia and is converted into cuprous imide, Cu_2NH. At higher temperatures cuprous imide is converted into cuprous nitride, Cu_3N.

The product of the general formula $Cu_3N.nNH_3$, dissolves in liquid ammonia solution of potassium amide to form a solution from which well crystallized specimens of a colorless salt of the compound represented by the formula, $CuNK_2.3NH_3$, have been obtained. This compound has been named potassium ammonocuprite for the reason that it obviously occupies a position in the ammonia system of acids, bases and salts entirely similar to that which the more familiar zincates, aluminates, plumbites, etc., occupy in the water system.

Potassium ammonocuprite with three molecules of ammonia of crystallization, or triammonated potassium ammonocuprite, readily loses

successively two molecules of ammonia to form the diammonated and monoammonated salts of the respective formulas $CuNK_2.2NH_3$ and $CuNK_2.NH_3$. E. C. F.

CHEMISTRY.—*Potassium ammonotitanate.* EDWARD C. FRANKLIN and THOMAS B. HINE. Journal of the American Chemical Society **36**: 1497. 1912.

Treated with liquid ammonia titanium tetrabromide undergoes ammonolysis and is converted into an ammonobasic titanium bromide of the formula $N \equiv Ti - Br$. When this basic salt, or nitride bromide, is brought into contact with liquid ammonia solution of potassium amide a reaction takes place which results in the formation of a compound of the formula $N \equiv Ti\text{-}NHK$ which receives the name potassium ammonotitanate. The two reactions are represented by the equations

$$TiBr_4 + 4NH_3 = N \equiv Ti - Br + 3NH_4Br \quad \text{and}$$
$$N \equiv Ti - Br + 2KNH_2 = N \equiv Ti - NHK + KBr.$$

The results of this investigation show that just as titanium bromide undergoes hydrolysis in contact with water and just as the product of hydrolysis may be made to react with potassium hydroxide to form potassium aquotitanate so similarly the bromide undergoes ammonolysis in contact with liquid ammonia and in presence of an excess of the ammonobase, potassium amide, it is converted into a potassium ammonotitanate. E. C. F.

CHEMISTRY.—*The action of potassium amide on thallium nitrate in liquid ammonia solutions.* EDWARD C. FRANKLIN. Hygienic Laboratory. Journal of Physical Chemistry **16**: 683. 1912.

The black precipitate of thallous nitride, formed by the interaction of liquid ammonia solutions of potassium amide and thallium nitrate in accordance with the equation, $TlNO_3 + 3KNH_2 = Tl_3N + 3KNO_3 + 2NH_3$, dissolves in potassium amide solution to form potassium ammonothallite. The salt thus formed separates from sufficiently concentrated solutions in the form of beautiful yellow crystals of the composition represented by the formula $TlNK_2.4NH_3$. The reaction between thallium nitride and potassium amide is strictly analogous to that which takes place when zinc oxide, for example, dissolves in aqueous solution of potassium hydroxide. Potassium aquozincate is formed in the latter case, potassium ammonothallite in the former. The salt readily loses ammonia to form successively the products represented respectively by the formulas $TlNK_2.2NH_3$ and $TlNK_2.1\frac{1}{3}NH_3$.

Mixed crystals or isomorphous mixtures varying in composition from that of pure potassium ammonothallite to that of a product represented by the formula $TlNK_2.4NH_3.3.6KNH_2$ have been obtained from liquid ammonia solutions of potassium ammonothallite containing an excess of potassium amide. E. C. F.

PALEONTOLOGY.—*Cambrian Brachiopoda.* CHARLES D. WALCOTT. Monographs of the U. S. Geological Survey **51**. Part I, text, pp. 872; Part II, pls. 104, pp. 363. 1912.

This monograph describes 44 genera, 15 subgenera, 477 species, and 59 varieties of Cambrian Brachiopoda, and 3 genera, 1 subgenus, 42 species, and 1 variety of Ordovician Brachiopoda. Of the Cambrian forms, 10 genera, 2 subgenera, 21 species, and 1 variety persist into the Ordovician.

In this paper the Brachiopoda are treated in three ways—historically, geologically, and zoologically. Historically the treatment comprises (1) a bibliography and (2) a table of synonymic reference, giving a completely cross-referenced list of described species with the present generic and specific reference of each. Geologically the distribution of the Brachiopoda is considered under the following headings: (1) General geographic and stratigraphic distribution; (2) detailed geographic distribution; (3) detailed stratigraphic distribution; (4) habitat; and (5) fossil localities. Zoologically the discussion covers (1) the physical characters of the Brachiopoda; (2) their distribution; (3) their evolution; and (4) their classification. Lastly come the detailed descriptions of genera and species and the illustrative plates. P. V. ROUNDY.

ZOOLOGY.—*On a collection of recent Crinoids from the waters about Ireland.* AUSTIN H. CLARK. Department of Agriculture and Technical Instruction for Ireland, Fisheries Branch; Scientific Investigations, 1912, no. IV, pp. 1–5. 1913.

The collection upon which this report is based was brought together by the Irish fishery cruiser *Helga* while working in the seas to the west and north of Ireland; the description of a single specimen taken in the Faeroe Channel by Dr. Wolfenden's yacht *Silver Belle* is also included.

Though small, the collection is of very considerable interest because four of the eight species represented are new to the coasts of the British Islands, one of these representing a genus heretofore known, in the Atlantic basin, only from the Caribbean Sea.

The eight species are: *Antedon petasus* (Düben and Koren) (not

previously reported from Ireland); *Leptometra celtica* (Barrett and McAndrew); *Hathrometra prolixa* (Sladen) (Faeroe Channel); *Trichometra hibernica*, sp. nov. (related to a species occurring off Newfoundland); *Trichometra delicata* (a species described in 1911 from the Bay of Biscay); *Pentametrocrinus atlanticus* (not hitherto known north of the Bay of Biscay) *Atelecrinus helgae*, sp. nov. (related to the Caribbean *A. balanoides*, and the first species of the genus to be discovered in the east Atlantic); and *Rhizocrinus lofotensis*. A. H. C.

BACTERIOLOGY.—*Further attempts to transmit poliomyelitis thru the agency of the stable fly (Stomoxys calcitrans)*. JOHN F. ANDERSON, Surgeon, U. S. Public Health Service, Director Hygienic Laboratory, and WADE H. FROST, Passed Assistant Surgeon, U. S. Public Health Service. Public Health Reports, 1913.

In an experiment conducted in October, 1912, we were able to infect monkeys with poliomyelitis by exposing them to the bites of several hundred *Stomoxys*, which were allowed, at the same time, to feed on monkeys inoculated intracerebrally with poliomyelitis virus. From the date of that experiment up to February, 1913, we have carried out a number of additional experiments designed to throw light upon the conditions necessary for the experimental transmission of poliomyelitis thru *Stomoxys calcitrans*. The flies used in our later experiments have been, in part, captured in the vicinity of the Hygienic Laboratory and, in part, bred in the laboratory. In a considerable number of our experiments we have undertaken to simulate summer conditions by maintaining a temperature of 75° to 85° F.

In these experiments monkeys inoculated with poliomyelitis have been exposed to large number of *Stomoxys* at various stages of their incubation period and during the period of developed symptoms. Fresh monkeys have been exposed to these same flies simultaneously with the inoculated monkeys and at various intervals thereafter. *Stomoxys* fed on defibrinated blood drawn from inoculated monkeys in all stages of the incubation period of the disease and others fed on mixtures of normal monkey blood with poliomyelitis virus, have been allowed to feed on fresh monkeys. In one experiment we inoculated a yearling colt intravenously and intracerebrally with a large amount of poliomyelitis virus and exposed this animal at once to some 2000 *Stomoxys*, which were then allowed to bite fresh monkeys. Neither the colt nor the monkeys showed symptoms in any way suggestive of poliomyelitis.

Two experiments were carried out with flies caught in the immedi-

ate vicinity of the residences of poliomyelitis patients in Buffalo, N. Y. These flies were then shipped to the Hygienic Laboratory and there allowed to feed upon fresh monkeys.

Contrary to what might have been expected from the results of our first experiment, we have been unable to transmit the infection thru *Stomoxys* in a single one of our later experiments. Up to this time we have found no satisfactory explanation for this discrepancy in results. The flies used in our later experiments have been generally as numerous and as active and have fed as freely as those used in our first experiment. In some of our later experiments the inoculated monkeys have been exposed as promptly after inoculation, that is, after only two hours; and, so far as we are able to see, all the conditions of our first experiment have been duplicated.

The question has occurred to us whether the season of the year has any peculiar influence upon the transmission of poliomyelitis thru the *Stomoxys*. Our own first experiment, as well as those of Rosenau and Brues, was carried out in the early autumn, during the season when poliomyelitis is commonly quite prevalent in nature. Our later experiments, in the late autumn and winter months, were carried out during a season when this disease is quite rare in nature; but in order to simulate summer conditions a temperature of 75° to 85° F. was maintained in the room where these experiments were carried out. Altho there is no apparent reason why the season alone, regardless of the temperature maintained, should have exerted any special influence upon the outcome of our experiments, it appears to us worth while to repeat the experiments during the summer and autumn months.

In the meantime, it is impossible to estimate accurately the importance which *Stomoxys* may play in the transmission of poliomyelitis. That it is an important natural factor appears to us doubtful, not only because of our own negative results but also because recent experiments have afforded additional evidence of the direct transmissibility of poliomyelitis and because epidemiological studies appear to us to indicate that the disease is probably transmitted largely through passive human virus carriers.

Nevertheless, our negative results need not be taken as conclusive. The demonstration of the infectiousness of the nasal and buccal secretions of poliomyelitis patients was made only after a considerable number of experiments had been performed with entirely negative results. The same is true of several other recently established facts in experimental poliomyelitis. J. F. A. and W. H. F.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE WASHINGTON ACADEMY OF SCIENCES

The 83d meeting of the Washington Academy of Sciences was held at the Cosmos Club, Saturday evening, March 1, 1913. The following were elected resident members of the Academy: BERT S. BUTLER, F. C. CALKINS, WILLIAM MANSFIELD CLARK, RICHARD B. DOLE, CLARENCE N. FENNER, H. L. FERGUSON, ARTHUR W. GRAY, HENRY HINDS, C. W. KANOLT, FRANK LEVERETT, F. L. LEWTON, GERALD L. LOUGHLIN, CURTIS F. MARBUT, HERBERT E. MERWIN, M. J. MUNN, J. B. NORTON W. A. ORTON, N. S. OSBORNE, L. A. ROGERS, WILLIAM H. ROSS, ROBERT B. SOSMAN, J. W. SPENCER, L. W. STEPHENSON, RODNEY H. TRUE, JOSEPH B. UMPLEBY, ROGER CLARK WELLS, FRANK WENNER.

After the election of new members, the Academy, in joint session with the Philosophical Society, listened to an address by the Right Honorable JAMES BRYCE, O. M., Ambassador to the United States, on *The physical aspects of Australia and New Zealand.*

The speaker's theme was a recent trip he had taken thru both these countries, and he made it broad enough to cover the most diverse subjects—the geography, the geology, the ethnology, the fauna, the flora, the history and the political economy of these great countries, all of which he made delightfully interesting by the aid of maps, charts, pictures, and by his own clearness and accuracy of description.

The 84th meeting of the Washington Academy of Sciences was held at the Cosmos Club, Monday evening, March 31, 1913. Dr. EDWARD C. FRANKLIN of the Hygienic Laboratory spoke on *Ammonia, with experiments.*

It was explained that many of the properties, both physical and chemical, of liquid ammonia are similar to those of water; and in particular that just as we have water derived acids, bases, and salts, or a water chemistry, so too there is an ammonia chemistry consisting of an extensive series of ammonia derived acids, bases, and salts. The parallel between the two chemistries, as Dr. Franklin's explanations made clear and his many ingenious experiments demonstrated is complete in every particular.

The 85th meeting of the Washington Academy of Sciences was held on April 23, 1913, at the Cosmos Club. Professor Dr. W. WIEN of the University of Würtzburg spoke on *Recent theories on heat and radiation.* Published in full in this Journal **3**: 273. 1913.

W. J. HUMPHREYS, *Recording Secretary.*

THE CHEMICAL SOCIETY

(LOCAL SECTION OF THE AMERICAN CHEMICAL SOCIETY)

The 224th meeting was held on March 13, 1913 at the George Washington University Medical School. President Waters in the chair.

Mr. SVERRE GULBRANDSEN, of the Welsbach Light Company, spoke on *Incandescent gas lighting*. After reviewing the early history of gas lighting by incandescent mantles, the speaker described the discoveries of Auer, and the present process of manufacture of mantles. One of the recent improvements in mantle manufacture consists in the use of squirted fibers of soluble cellulose. The properties of the mantle depend primarily upon those of the original supporting fiber. Mantles from artificial fiber show less shrinkage and hence less loss of luminosity, and also less weakening with age, than those from natural fibers. They are also about three times as strong initially, as the lecturer showed experimentally.

The 225th meeting was held at the Cosmos Club on April 11, 1913.

Prof. RALPH S. LILLIE of the University of Pennsylvania spoke on the subject, *Physico-chemical conditions of anesthetic action*. Some conditions that produce effects akin to anesthesia are: lowering of temperature, lack of oxygen, mechanical shock, and exposure to electric current. The effect of a steady small current may be to increase or decrease the irritability of nerve or muscle, depending on the effect of the current upon the potential differences at the cell membranes. The plasmal membrane of cells is a very important factor in their reaction toward substances in solution. These membranes are semipermeable with respect to some solutes, and are freely permeable to others, the latter being usually lipoid-soluble substances. Experiments with electric currents of different frequencies give evidence that the seat of the most constant and characteristic phenomenon of irritability, namely, the electric potential difference, lies in the semipermeable membrane of the cell. Change in irritability is also accompanied by a change in the permeability of the membrane. Anesthetic substances change the susceptibility of a membrane to those changes of permeability which are necessary to stimulation. Experiments by the author on marine organisms whose cells contain a rapidly diffusing pigment show clearly that the anesthetic effect of certain salts is due to their effect on the susceptibility of the cell membrane to permeability increase and not to their effect on the cell contents. The lipoid-soluble anesthetics, such as ethyl ether, all act in the same way as the salts. It appears that the primary process in stimulation is a membrane process, and the effect of anesthesia is upon this primary process. The chemical explanation of this effect is unknown, but may be due to a disturbance of the mutual relations of the colloids of the membrane.

Discussion. WELLS spoke of the many different causes of electric potentials in liquids, and inquired whether oxidation and reduction potentials might not be operative. Professor LILLIE replied that a

number of theories in addition to those he had given had been suggested for these potentials, and the subject is still unsettled. The fact remains that if the semipermeability of the membrane is destroyed, the potential difference is lowered or disappears. To an inquiry by BERG, as to the bearing of certain experiments on the injection of lecithin-saturated ether upon the theory, it was replied that these experiments do not settle the point. GORE inquired as to the effect of calcium salts.

The 226th meeting was held at the Cosmos Club on Friday, May 2, 1913.

Prof. EUGENE C. BINGHAM, of Richmond College, Richmond, Va., spoke on the subject, *Fluidity and its relation to other physical and chemical properties.* Viscosity and fluidity were first defined, and their analogy to electric resistance and conductance brought out. The evidence shows that fluidities and not viscosities are additive. For this reason the relation of fluidity to temperature approaches a straight line. Liquid emulsions and solid suspensions, as well as mixtures of liquids, have been studied by the author. In the case of emulsions, viscosity tends to be additive, as expected. In suspensions, zero fluidity appears at a percentage composition far below that at which the mixture ceases to flow visibly. This composition is believed to represent the dividing line between viscous and plastic flow. In accordance with theory, the zero of fluidity is independent of the liquid and of the temperature. The lecturer then showed many examples of the use of fluidity curves in interpreting the constitution and relations of mixtures of organic liquids, for instance, the indication of a compound between ether and chloroform. The lecture was illustrated by lantern slides and experiments.

Discussion. SOSMAN inquired whether a crystalline compound of ether and chloroform is known, corresponding to that shown by the fluidity curve. Professor BINGHAM knew of none. In reply to inquiry by FORD, as to why the curves of zero fluidity were not carried nearer zero, Professor BINGHAM stated that the solid settles out and closes the capillary. BUNZEL mentioned the application of these facts to milk and casein suspensions. The discussion led into the question of the cause of emulsification by dilute alkaline solutions; Professor BINGHAM believed this due in part to the formation of films from the fatty acid or saponifiable oil which might be present. FORD quoted experiments of SPRING in opposition to this view. In reply to a question by BERG, it was stated that the condition of the surface of the solid does not affect the value of fluidity obtained. In support of Professor BINGHAM'S view BERG quoted the fact that olive oil, when entirely free from acid, is not emulsified by soda, altho it becomes emulsifiable on standing in air. SOSMAN mentioned the reciprocal relation of density and volume as similar to that of viscosity and fluidity, and spoke of some misconceptions that have arisen because density, instead of volume, was assumed to be the additive property.

C. L. PARSONS gave a brief report on the Milwaukee meeting of the American Chemical Society.

The 227th meeting was held at the Cosmos Club on Thursday, May 8. The following papers were read:

H. C. FULLER, of the Institute of Industrial Research: *The determination of caffein in tea and coffee.* (Read by Mr. WETTENGEL.) The method recommended by the author depends upon the separation of the caffein from the body of the vegetable matter by means of acidulated water, and its extraction from the decoction with chloroform. The caffein is then purified by precipitation with iodin, the iodide is decomposed and the pure alkaloid finally extracted with chloroform.

W. B. HICKS, of the Geological Survey: *A short practical method for the estimation of potassium.* The method consists in the precipitation of potassium by platinum chloride from the acidified solution, washing with alcohol, solution in hot water, and reduction of the chlorplatinate by metallic magnesium to obtain the platinum in a weighable form. The method is applicable in presence of a variety of other salts, and has been used by the author in the analysis of salines.

Discussion. In reply to questions by YODER and GRANT, the speaker pointed out that the presence of non-volatile salts would interfere with the determination of the platinum by simple ignition. In reply to a question by SEIDELL, it was shown that sodium chlorplatinate is dissolved out by alcohol, and does not interfere.

R. C. WELLS, of the Geological Survey: *Quantitative relations between oxidizing and reducing solutions.* The use of oxygen and hydrogen electrodes for measuring oxidation and reduction potentials in solutions, such as ferrous and ferric solutions, is rendered possible by the use of platinum. Acidity increases the oxidation potential, while alkalinity increases the reduction potential. The degree of reproducibility of these potentials was discussed. The oxygen and hydrogen potentials in pure water can be calculated, as well as their change with the gas pressure, and the two are found to become equal at 0.68 volt and at 10^{-25} atmosphere. This potential marks the true boundary between oxidizing and reducing solutions. Very nearly the same value is obtained by calculation from the known dissociation constant of water at high temperatures.

Discussion. BLUM inquired as to contact potentials in the liquid circuit; these are small in comparison with the potentials measured. YODER inquired whether potential measurements could be used to determine acidity in soil solutions; this would be difficult in the presence of oxidizing substances. SULLIVAN suggested an application to biochemical studies. FRANKLIN inquired further as to the ferrous-ferric equilibrium. BLUM stated that the hydrogen electrode has been successfully used for determining acidity in materials such as vinegar and wines.

H. C. GORE, of the Bureau of Chemistry: *The biochemistry of the banana.* Experiments have been made on the ripening of bananas in a respiration calorimeter and in humidors. During ripening the starch decreases, reducing sugars and sucrose increase, and total solids decrease, both in the pulp and peel. There is a considerable increase in the amount of water in the pulp. The respiration rate reaches a maximum

at the time when the starch is decreasing most rapidly. A considerable amount of water is absorbed in the hydrolysis of starch, and water is produced by oxidation; the net result may be either a loss or gain in free water. About 2 per cent of the sugar is oxidized.

Discussion. The change in flavor at the end of ripening was discussed by FRANKLIN, GORE and CHESNUT. The point was brought out by SULLIVAN, FRANKLIN and SOSMAN that manganese dioxide, which is present in banana peel, acts like a reducing agent or a catalyzer for reduction. It was stated in reply to questions that bananas are usually ripened off the trees. Means for accelerating or retarding ripening were discussed by MCBRIDE, FRANKLIN, HILLEBRAND and GORE. The latter stated that experiments are planned on the effect of carbon dioxide (asphyxiation).

ROBERT B. SOSMAN, *Secretary.*

THE GEOLOGICAL SOCIETY OF WASHINGTON

The 269th meeting was held on April 9, 1913, at the Cosmos Club. In the open meeting E. O. ULRICH spoke concerning the age of the Bays sandstone of the Appalachian Valley. New fossils from the type locality prove this exposure at least to be of Black River age.

REGULAR PROGRAM

The mud lumps at the mouth of the Mississippi (illustrated): E. W. SHAW. The "Mud Lumps" are remarkable swellings of dark blue clay in the shallow water at the mouths of the Mississippi. They commonly form islands with a surface extent of an acre or more and a height of 5 or 6 feet. They have always been a serious obstacle to navigation but with the exception of several papers written by Hilgard the published literature concerning them seems meagre when we consider the unusual and important character of the phenomenon. The present paper is only a preliminary notice and a statement of working hypotheses. The principal new hypothesis is that the delta is affected by a bodily seaward flowage and that the mud lumps are incidental to this flowage. This involves the assumption that the outer beds are sandy and comparatively rigid whereas Hilgard believes that just off shore the deposit consists of very watery clay. He sets forth that a crust of sand and silt are built out over this watery clay giving an unstable condition and that wherever the crust is weak the sludge breaks up thru, forming mud lumps. He also thinks that the mud springs which are found on many lumps are vents for the fluid mud underneath. To the present writer these seemed to be incidental to fissuring produced by mud lump upheaval.

A reconnaissance of the Arctic Slope of Alaska: E. DE K. LEFFINGWELL. This area is bounded by the Canning River on the west and by the Okpelak River on the east, and extends inland for about 80 miles. Two provinces are recognized, the Arctic Mountains and the Arctic

Slope. The former, composed chiefly of pre-Mesozoic rocks, extend east and west across Arctic Alaska, and are regarded as a continuation of the Rocky Mountain System of the United States and Canada. The Arctic Slope is divided into the Anaktovuk Plateau and the Coastal Plain. The former is a rolling upland forming the northern front of the mountains and is composed chiefly of Mesozoic and Tertiary rocks. The latter is a nearly featureless plain of Pleistocene rocks. The drainage is characterized by a series of closely spaced rivers flowing nearly north from the mountains to the Arctic Ocean.

Schists of probable pre-Cambrian age were deposited and metamorphosed early in the history of the region. The earliest sedimentation of definite age took place in Carboniferous time, when the European section was closely followed. Only 300 feet intervene between the Geschellian and upper Triassic. A series of marine post-Triassic rocks, whose faunas have not yet been studied, probably represent the Jurassic and perhaps extend into the Cretaceous. Evidence from neighboring areas indicates that the Arctic Mountains were deformed in early Tertiary times. Their general accord of summits may indicate base-leveling, but the lack of definite evidence leaves it an open question. The tilted and leveled Pliocene rocks in the Anaktovuk Plateau indicate that this area was uplifted and base-leveled in late Pliocene or early Pleistocene times. The Coastal Plain was uplifted in the Pleistocene, probably before the Wisconsin stage of glaciation. Since then there have been minor oscillations probably less than 25 feet in amount.

Ores of the Mount Lyell copper district of Tasmania (illustrated): C. C. GILBERT and J. E. POGUE. Two types of deposits are represented, typified in the two largest mines of the district. The Mount Lyell mine opens up a pyritic mass of immense size, low in copper content but with values in gold and silver. The ore is densely granular pyrite, bearing thruout chalcopyrite in minute stringers and filaments and including localized areas of tetrahedrite and of enargite. Bornite, chalcopyrite, sphalerite, and galena are also present but in subordinate amounts. At the North Mount Lyell mine the ore minerals, in order of importance, are bornite, chalcopyrite, chalcocite, tetrahedrite, and pyrite; these form mineralized zones in the schists and not a great pyrite body as at Mount Lyell. Metallographic study of polished sections indicates that both types of deposits were dominantly formed thru replacement of the minerals of the schists, and that the deposition took place during a distinct mineralizing epoch marked by solutions progressively changing in composition and depositing a series of sulfide minerals in sequential and transitional stages. The order of deposition among the principal minerals is pyrite, chalcopyrite, bornite, chalcocite, corresponding to a decreasing iron and increasing copper content. Enargite and tetrahedrite probably mark a late stage in the mineralizing epoch; with these chalcopyrite of a second generation is associated. The sections give no conclusive evidence of secondary sulfide enrichment. The ores studied are the property of the U. S. National Museum.

RALPH W. RICHARDS, *Secretary.*

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